(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 389 221 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **90302930.4**

(22) Date of filing: **19.03.90**

(51) Int. Cl.5: **B23H 9/12, B23H 1/04, B23H 5/04**

(30) Priority: **20.03.89 JP 68806/89**

(43) Date of publication of application:
26.09.90 Bulletin 90/39

(84) Designated Contracting States:
BE DE FR GB IT SE

(71) Applicant: **NGK INSULATORS, LTD.**
2-56, Suda-cho, Mizuho-ku
Nagoya City Aichi Pref.(JP)

Applicant: **INSTITUTE OF TECHNOLOGY PRECISION ELECTRICAL DISCHARGE WORKS**
283 Shimohirama Saiwai-ku
Kawasaki City Kanagawa Prefecture(JP)

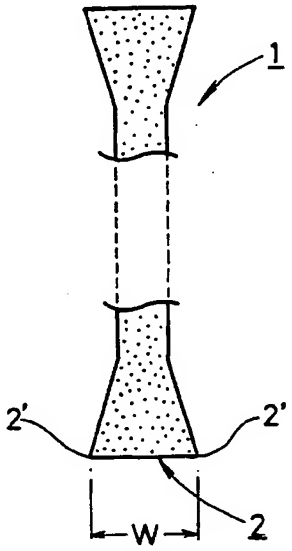
(72) Inventor: **Hattori, Isao, 30, Aza-Inowari**
Ohaza-Fukutamaeshinden, Nanyou-cho
Minato-ku, Nagoya-city, Aichi Pref., 455(JP)
Inventor: **Futamura, Shoji, c/o Institute of Technology**
Prec. Electr. Dis. Work, 283 Shimohirama
Saiwai-ku
Kawasaki-city, Kanagawa-pref., 211(JP)

(74) Representative: **Paget, Hugh Charles Edward et al**
MEWBURN ELLIS 2 Cursitor Street
London EC4A 1BQ(GB)

(54) Production method of honeycomb die-forming electrical discharge machining electrodes and production method of honeycomb dies.

(57) When producing an electrical discharge machining electrode (3) for use in forming a honeycomb-making die, a plurality of grooves (4) are cut in an electrode material by a grinding wheel (1) formed with a reverse tapered shape in which the grinding width is gradually widened toward its periphery. Subsequent to the cutting of a groove, the grinding wheel and the electrode material are relatively moved by an integral number of pitches in a direction perpendicular to the grinding direction, and the grinding surface of the grinding wheel is dressed after a desired number of such pitch movements to narrow the grinding width. Thereby a plurality of projecting electrode portions (5) are formed between the electrode grooves and the thickness of the projecting electrode portions are controlled so as to increase continuously or stepwise.

FIG.1



EP 0 389 221 A1

between their corresponding electrode groove portions, the improvement wherein:
the grinding wheel is formed into a reverse tapered shape in which the grinding width is gradually widened toward its peripheral direction; and
a plurality of grooves are cut in the electrode material by moving the grinding wheel relative to the electrode material so as to cut a groove in the electrode material, and subsequent to the cutting of the groove, relatively moving the grinding wheel and the electrode material by desired pitches in a direction perpendicular to the grinding direction, and dressing the grinding surface of the grinding wheel at plural pitch distances relative to the movement of the grinding wheel and the electrode material toward the directions of both ends from the center portion for the purpose of narrowing the grinding width, whereby a plurality of electrode groove portions are formed.

Yet further this invention can provide a method for the production of a honeycomb die provided with forming grooves, which have configurations corresponding to the profile of a honeycomb structure and are to be formed by electrical discharge machining making use of a honeycomb die-forming electrical discharge machining electrode provided with a plurality of projecting electrode portions corresponding to the forming grooves, which comprises;
using, as the honeycomb die-forming electrical discharge machining electrode, a honeycomb die-forming electrical discharge machining electrode provided with a plurality of electrode groove portions, which have been formed by cutting a plurality of grooves in an electrode material while moving a grinding wheel formed into a reverse tapered shape, in which the grinding width is gradually widened toward its peripheral direction, relative to the electrode material so as to cut a groove in the electrode material, and subsequent to the cutting of the groove, relatively moving the grinding wheel and the electrode material by desired pitches in a direction perpendicular to the grinding direction, and dressing the grinding surface of the grinding wheel at every pitch width relative to the movement of the grinding wheel and the electrode material toward the directions of both ends from the center portion for the purpose of narrowing the grinding width, and at the same time provided with a plurality of projecting electrode portions formed between their corresponding electrode groove portions, owing to the formation of the plural electrode groove portions, in such a manner that the dimensions in thickness of the plural projecting electrode portions become greater continuously toward both ends from the center of the electrode.

In another aspect this invention can provide a method for the production of the honeycomb die, further comprising:
cutting forming grooves being in rows in one direction relative to a material to be formed by electrical discharge machining making use of the honeycomb die-forming electrical discharge machining electrode; and
cutting forming grooves in a direction crossing perpendicularly to said one direction by electrical discharge machining making use of the honeycomb die-forming electrical discharge machining electrode in a condition that the honeycomb die-forming electrical discharge machining electrode and the material to be formed have been relatively rotated by 90°, thereby cutting forming grooves, whose dimensions in width become greater continuously toward both ends from the center, in the honeycomb die.

Yet further this invention can provide a method for the production of a honeycomb die provided with forming grooves, which have configurations corresponding to the profile of a honeycomb structure to be formed and are to be formed by electrical discharge machining using a honeycomb die-forming electrical discharge machining electrode provided with a plurality of projecting electrode portions corresponding to the forming grooves, which comprises;
using, as the honeycomb die-forming electrical discharge machining electrode, a honeycomb die-forming electrical discharge machining electrode provided with a plurality of electrode groove portions, which have been formed by cutting a plurality of grooves in an electrode material while moving a grinding wheel formed into a reverse tapered shape, in which the grinding width is gradually widened toward its peripheral direction, relative to the electrode material so as to cut a groove in the electrode material, and subsequent to the cutting of the groove, relatively moving the grinding wheel and the electrode material by desired pitches in a direction perpendicular to the grinding direction, and dressing the grinding surface of the grinding wheel at plural pitch distances relative to the movement of the grinding wheel and the electrode material toward the directions of both ends from the center portion for the purpose of narrowing the grinding width, and at the same time provided with a plurality of projecting electrode portions formed between their corresponding electrode groove portions, owing to the formation of the plural electrode groove portions, in such a manner that the thicknesses of the plural projecting electrode portions become greater stepwise toward both ends from the center of the electrode;
cutting, as a first machining step, forming grooves being in rows in one direction relative to a material to be formed by electrical discharge machining making use of the honeycomb die-forming elec-

a distance P in a -X direction to cut a groove so as to form a electrode groove portion 4(-1). As a result, a projecting electrode portion 5(0) having a thickness of t_0 is formed between the electrode groove portions 4(1) and 4(-1). The grinding width W is then changed from W_1 to W_2 by dressing and at the same time, the grinding wheel 1 is moved by a distance P in the -X direction. A groove is then cut to form a electrode groove portion 4(-2), whereby a projecting electrode portion 5(-1) having a thickness of t_1 is formed between the electrode groove portion 4(-2) and the electrode groove portions 4(-1). By the way, supposing $(t_1 - t_0)$ is Δt, the grinding width W_2 is $(W_1 - 2x\Delta t)$. The grinding wheel 1 is then moved by a distance 3P in an X direction. A groove is cut to form a electrode groove portion 4(2). As a result, a projecting electrode portion 5(1) having a thickness of t_1 is formed between the electrode groove portions 4(1) and the electrode groove portion 4(2). Thereafter, the grinding surface 2 of the grinding wheel 1 is dressed in order in the same manner as described above to cut grooves of electrode groove portions 4(3), 4(-3), ..., thereby forming projecting electrode portions 5(2), 5(-2), ... As a result, an electrode 6 having a shape of comb's teeth in cross section in the X - (-X) direction, as illustrated in FIG. 2, and depicted in FIG. 3 is produced. Incidentally, in the description of the production process of the above electrode 6, the description has been given as moving the grinding wheel 1. However, the electrode material 3 may be caused to move. A perspective view of the electrode 6 thus produced is shown in FIG. 5.

The production method of an electrode 7 illustrated in FIG. 4 is basically the same as that of the electrode 6. Namely, in the production of the electrode 6, the dressing of the grinding wheel 1 has been conducted every other groove cutting, i.e., formation of every two electrode groove portions. In the production of the electrode 7, the dressing may however be conducted at every fourth or sixth groove cutting, i.e., formation of every four or six electrode groove portions. As a result, the electrode 7, as is indicated by a step-like line B drawn in the lower part of FIG. 4, is formed in such a manner that supposing the thickness of the projecting electrode portion 5(0) situated at the center is t_0, the thicknesses t of the projecting electrode portions 5 become greater stepwise toward X and -X directions. Incidentally, in the embodiment illustrated in FIG. 4, the thicknesses t of the projecting electrode portions 5 have been changed at three steps. However, such changes are not limited thereto. It is also possible to change the thicknesses t of the projecting electrode portions at every two steps, or four steps or more.

The production method of honeycomb dies according to this invention, in which forming grooves for forming honeycomb structures are cut by electrical discharge machining making separate use of the electrodes 6 and 7, is then described with reference to FIGS. 6 and 7.

A honeycomb die 8 illustrated in FIG. 6 has forming grooves 10 cut by electrical discharge machining making use of the electrode 6. The honeycomb die 8 is formed in the following manner. Namely, after forming grooves 10-1 in an X - (-X) direction by way of example are cut by the electrical discharge machining making use of the electrode 6, forming grooves 10-2 in a Y - (-Y) direction are cut in a condition that the electrode 6 has been rotated by 90°. Since the electrode 6 has been formed in such a manner that supposing the thickness of the projecting electrode portion 5(0) situated at the center is t_0, the thicknesses t of the projecting electrode portions 5 become greater continuously toward X and -X directions, the groove widths V of the forming grooves 10 in the honeycomb die 8, as is indicated by a V-shaped line A drawn in the lower part of FIG. 6, are defined in such a manner that they correspond respectively to the thicknesses t_0, ..., and t_n and t_n of the projecting electrode portions 5(0), ..., and 5(n) and 5(-n) in the electrode 6, and become greater continuously toward X and -X directions and Y and -Y directions, supposing the groove width of the forming groove 10 situated at the center is V_0. A perspective view of the honeycomb die 8 thus produced is shown in FIG. 8.

A honeycomb die 9 illustrated in FIG. 7 has forming grooves 10 cut by electrical discharge machining making use of the electrode 7. The honeycomb die 9 is formed in the following manner. Namely, after forming grooves 10-1 in an X - (-X) direction by way of example are cut by the electrical discharge machining making use of the electrode 7, forming grooves 10-2 in a Y - (-Y) direction are cut in a condition that the electrode 7 has been rotated by 90°. Since the electrode 7 has been formed in such a manner that supposing the thickness of the projecting electrode portion 5(0) situated at the center is t_0, the thicknesses t of the projecting electrode portions 5 become greater stepwise toward X and -X directions, the groove widths V of the forming grooves 10 in the honeycomb die 9, as is indicated by a step-like line B drawn in the lower part of FIG. 7, are defined in such a manner that they correspond respectively to the thicknesses t_0, ..., and t_n and t_n of the projecting electrode portions 5(0), ..., and 5(n) and 5(-n) in the electrode 7, and become greater stepwise toward X and -X directions and Y and -Y directions, supposing the groove width of the forming groove 10 situated at the center is V_0. Incidentally, in the embodiment illustrated in FIG. 7, the groove widths V of the forming grooves 10 have been changed at

shape, in which the grinding width is gradually widened toward its peripheral direction, relative to the electrode material so as to cut a groove in the electrode material, and subsequent to the cutting of the groove, relatively moving the grinding wheel and the electrode material by desired pitches in a direction perpendicular to the grinding direction, and dressing the grinding surface of the grinding wheel at every pitch width relative to the movement of the grinding wheel and the electrode material toward the directions of both ends from the center portion for the purpose of narrowing the grinding width, and at the same time provided with a plurality of projecting electrode portions formed between their corresponding electrode groove portions, owing to the formation of the plural electrode groove portions, in such a manner that the dimensions in thickness of the plural projecting electrode portions become greater continuously toward both ends from the center of the electrode.

5. The method of claim 4 further comprising:

cutting forming grooves being in rows in one direction relative to a material to be formed by electrical discharge machining making use of the honeycomb die-forming electrical discharge machining electrode; and

cutting forming grooves in a direction crossing perpendicularly to said one direction by electrical discharge machining making use of the honeycomb die-forming electrical discharge machining electrode in a condition that the honeycomb die-forming electrical discharge machining electrode and the material to be formed have been relatively rotated by 90°, thereby cutting forming grooves, whose dimensions in width become greater continuously toward both ends from the center, in the honeycomb die.

6. A method for the production of a honeycomb die provided with forming grooves, which have configurations corresponding to the profile of a honeycomb structure to be formed and are to be formed by electrical discharge machining using a honeycomb die-forming electrical discharge machining electrode provided with a plurality of projecting electrode portions corresponding to the forming grooves, which comprises;

using, as the honeycomb die-forming electrical discharge machining electrode, a honeycomb die-forming electrical discharge machining electrode provided with a plurality of electrode groove portions, which have been formed by cutting a plurality of grooves in an electrode material while moving a grinding wheel formed into a reverse tapered shape, in which the grinding width is gradually widened toward its peripheral direction, relative to the electrode material so as to cut a groove in the electrode material, and subsequent to the cutting of the groove, relatively moving the grinding wheel and the electrode material by desired pitches in a direction perpendicular to the grinding direction, and dressing the grinding surface of the grinding wheel at plural pitch distances relative to the movement of the grinding wheel and the electrode material toward the directions of both ends from the center portion for the purpose of narrowing the grinding width, and at the same time provided with a plurality of projecting electrode portions formed between their corresponding electrode groove portions, owing to the formation of the plural electrode groove portions, in such a manner that the thicknesses of the plural projecting electrode portions become greater stepwise toward both ends from the center of the electrode;

cutting, as a first machining step, forming grooves being in rows in one direction relative to a material to be formed by electrical discharge machining making use of the honeycomb die-forming electrical discharge machining electrode; and

after completion of the first machining step, cutting, as a second machining step, forming grooves in a direction crossing perpendicularly to said one direction by electrical discharge machining making use of the honeycomb die-forming electrical discharge machining electrode in a condition that the honeycomb die-forming electrical discharge machining electrode and the material to be formed have been relatively rotated 90°;

thereby cutting forming grooves, whose dimensions in width become greater stepwise toward both ends from the center, in the honeycomb die.

FIG.3

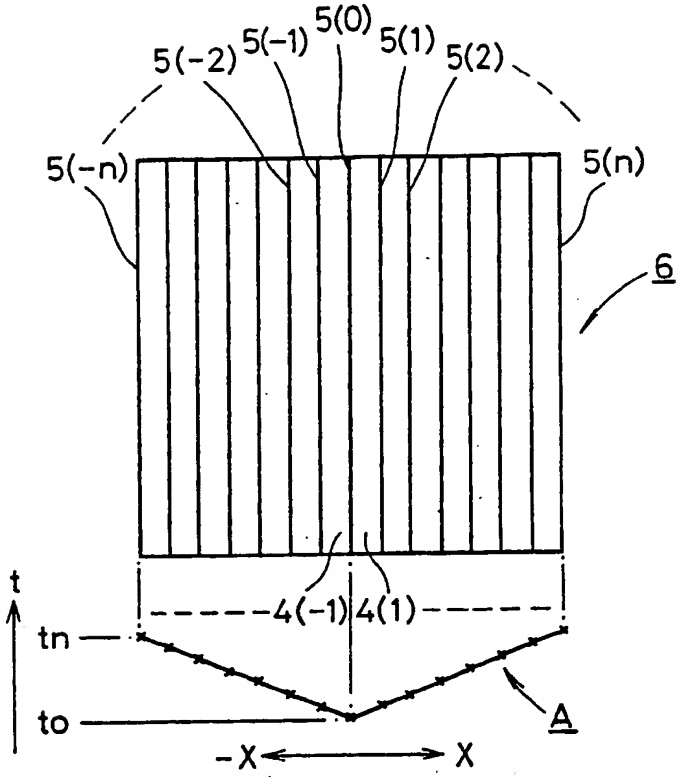


FIG.4

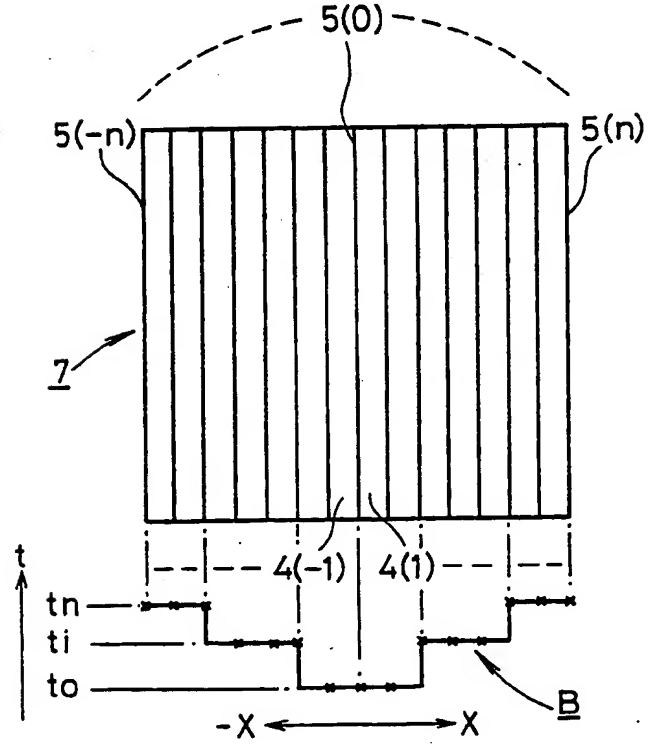


FIG.6

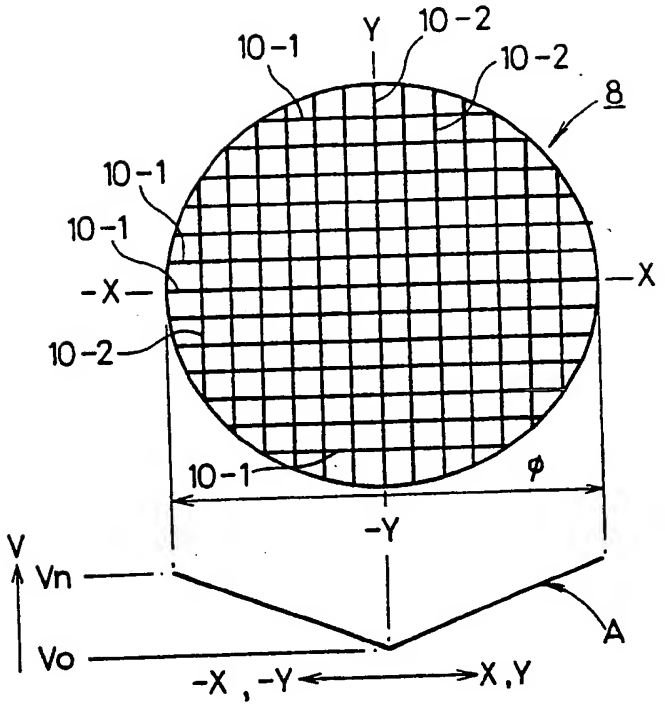
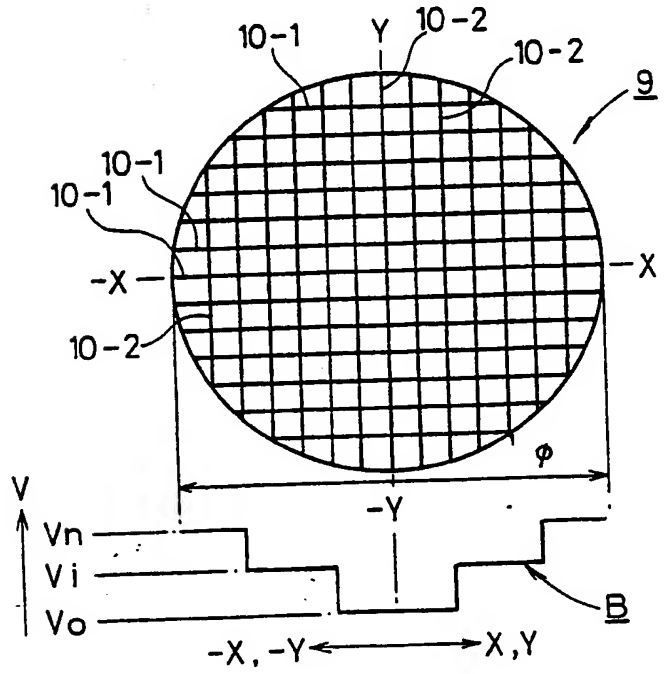

Y
10-1
10-2
10-2
8
10-1
10-1
-X
X
10-2
10-1
φ
-Y
V
Vn
A
Vo
-X , -Y
X , Y

FIG.7


10-1
Y
10-2
10-2
9
10-1
10-1
-X
X
10-2
φ
-Y
V
Vn
Vi
Vo
B
-X , -Y
X , Y

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 90302930.4

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl⁵)
A	US - A - 4 350 865 (BACHRACH) * Abstract; column 3, line 50 - column 4, line 33; claims 1,6; fig. 1,3 *	1,3,4, 6	B 23 H 9/12 B 23 H 1/04 B 23 H 5/04
A	SOVIET INVENTIONS ILLUSTRATED, Ch section, week 8444, December 12, 1984 DERWENT PUBLICATIONS LTD., London, M 11 * SU 1079-394-A (KUIB AVIATION INST) *	1,3,4, 6	
A	DE - A1 - 2 600 760 (SKF) * Page 6, lines 1-13; claim 1; fig. 1-3 *	1,3,4, 6	

TECHNICAL FIELDS SEARCHED (Int Cl⁵)

B 23 H 1/00
B 23 H 3/00
B 23 H 5/00
B 23 H 7/00
B 23 H 9/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	31-05-1990	TSILIDIS

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO Form 1503 03.82